

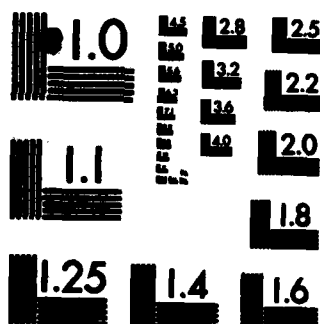
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August 31, 1984

Dr. Douglas Smith, Program Director
Information Sciences Program
Office of Naval Research
Department of the Navy
800 N. Quincy Street
Arlington, Virginia 22217

QUARTERLY PROGRESS REPORT

ONR TASK AUTHORITY IDENTIFICATION NUMBER: NR 049-479

CONTRACTOR: The Board of Trustees of the
Leland Stanford Junior University

CONTRACT NO.: N00014-81-K-0004

CONTRACT AMOUNT: \$968,370

EFFECTIVE DATE OF CONTRACT: January 1, 1981

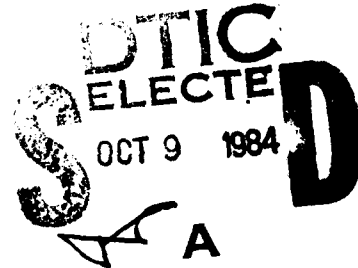
EXPIRATION DATE OF CONTRACT: December 31, 1986

PRINCIPAL INVESTIGATOR: Michael R. Genesereth

TELEPHONE NO.: (415) 497-0324

SHORT TITLE OF WORK: Research on Introspective Systems

REPORTING PERIOD: January 1, 1984 - June 30, 1984



DESCRIPTION OF PROGRESS (JANUARY - JUNE 1984)

Administrative

This contract represents the continuation of a three-year contract that commenced in January 1981 under the title "The Development of Representation Methods to Facilitate Knowledge Acquisition and Exposition in Expert Systems." With the renewal of the contract in January 1984, we have reversed the roles of the principal investigator and co-principal investigator. Thus Professor

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Michael Genesereth has taken over primary responsibility for the contract, but Dr. Edward Shortliffe remains involved as co-investigator and director of the explanation research discussed below.

Introspective Systems

The successful release of MRS last year allowed us to turn our attentions at the beginning of this year to more theoretical issues, with the intention of implementing them later in 1984. One of the most obvious of these has been the incorporation of uncertain reasoning facilities into MRS itself; the mathematics underlying this was developed during the first half of the year, and the results have been implemented in several small-scale applications.

→ A longer term project involves the creation of facilities for the compilation of MRS programs. Work on this has begun, and ²proto-compilers have been written to handle the process of drawing inference by either backward or forward chaining. More theoretical research is under way to investigate the possibility of automatically determining at compile time which of these two methods is the most effective for a specific application.

Issues of runtime control have also been studied. Our attention in this area has been focussed primarily on the problem of recursive inference; reasonably effective methods have been developed and implemented for dealing with this.

General research has also been undertaken with regard to the presentation of the results of an AI program, be it MRS in particular or a more general problem. Standards have been developed whereby the power and expressiveness of competing presentation languages may be evaluated.

Other theoretical work completed during the past six months has been an investigation of the oconnections between McCarthy's circumscription and the other paradigms for non-monotonic reasoning, and the development of strategies and protocols for distributing deduction between several large processors. With an eye toward an eventual development of a learning facility within MRS, a version space algorithm has been implemented, and research begun on the automatic generation of experiments by machine. ←

Explanation Project

The series of ONR-supported projects dealing with explanation capabilities for advice systems has continued during the past quarter. The most mature work is that of John Kunz in his system

Greg Cooper's NESTOR work is complete and his dissertation report will be completed by the end of the summer. That system is novel in its use of a Bayesian scoring function that avoids the assumption of conditional independence by utilizing causal knowledge of the domain. A branch and bound search technique is used to prune the search space, and emphasis is placed on allowing the user to guide the system's hypothesis generation and analysis. The "critiquing" approach to interaction is used, thereby placing an emphasis on explanatory capabilities. Much of the past quarter has been spent on evaluation experiments to determine the validity of the scoring approach used.

Curtis Langlotz continues to work on the problem of critiquing for the ONCOCIN system as described in past reports. His paper on the early critiquing work appeared in late 1983 (see publications list). As the work has transitioned to professional workstations, Curt has turned to the development of a simulation environment that will allow the system to offer explanations based on deeper mechanistic models of physiology and drug action. We expect the simulation system to be sufficiently completed by the end of the summer that it will be able to support early experiments within the ONCOCIN domain.

Finally, although Shoko Tsuji is no longer at Stanford, she and Dr. Shortliffe are completing a paper based on her ONR-supported work when she was a student. That paper should be ready for submission by the autumn.

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PUBLICATIONS

Papers/Reports:

- Genesereth, M.R. "Partial programs", Stanford University Heuristic Programming Project, January 1984
- Genesereth, M.R. and Smith, D.E. "Controlling recursive inference", Stanford University Heuristic Programming Project, May 1984
- Ginsberg, M.L. "Non-monotonic reasoning using Dempster's rule", to be presented at AAAI-84, Austin, Texas, August 1984
- Ginsberg, M.L. "Analyzing incomplete information", Stanford University Heuristic Programming Project, June 1984
- Ginsberg, M.L. "Implementing probabilistic reasoning", Stanford University Heuristic Programming Project, June 1984
- Greiner, R. and Genesereth, M.R. "The role of abstractions in understanding analogy", Stanford University Heuristic Programming Project, April 1984 at AAAI-83, Washington, D. C., August 1983.
- Mackinlay, J. and Genesereth, M.R. "Implicit language", Stanford University Heuristic Programming Project, March 1984
- Mackinlay, J. and Genesereth, M.R. "Expressiveness of languages", to be presented to AAAI-84, Austin, Texas, August 1984
- Smith, D.E. and Genesereth, M.R. "Controlling recursive inferences", Stanford University Heuristic Programming Project, March 1984
- Singh, V. and Genesereth, M.R. "A variable supply model for distributing deductions", Stanford University Heuristic Programming Project, May 1984
- Duda, R.O. and Shortliffe, E.H. Expert systems research. Science, 220:261-268 (1983).
- Langlotz, C.P. and Shortliffe, E.H. Adapting a consultation system to critique user plans. International Journal of Man-Machine Studies 19:479-496 (1983).
- Tsuji, S. and Shortliffe, E.H. Graphical access to the knowledge base of a medical consultation system. Proceedings of AAMSI Congress 83, pp. 551-555, San Francisco, Ca., May 1983.
- Healing, D.W., Clancey, W.J., and Rennels, G. Strategic explanations for a diagnostic consultation system. International Journal of Man-Machine Studies 20:3-19 (1984).
- Shortliffe, E.H. Explanation capabilities for medical consultation systems (tutorial), Proceedings of AAMSI Congress 84, pp. 193-197, San Francisco, Ca., May 1984.

Kunz, J.C. Use of Artificial Intelligence and Simple Mathematics to Analyze a Physiologic Model, PhD dissertation, Computer Science Department, Stanford University, June 1984.

Papers/Reports in Progress:

Cooper, G.F. NESTOR: A Computer-Based Medical Diagnostic Aid that Integrates Causal and Probabilistic Reasoning (thesis).

Tsuji, S. and Shortliffe, E.H. Graphics for knowledge engineers: A window on knowledge base management, (in preparation).

Conferences and Talks

Profs. Genesereth and Shortliffe have lectured widely both at Stanford and elsewhere during the last several months. Since January 1984 the talks most pertinent to this contract include the following:

- M.R. Genesereth: "Procedural hints in the control of reasoning", Teknowledge, Palo Alto, California, February 1984
- M.R. Genesereth: "Procedural hints in the control of reasoning", Carnegie-Mellon University, Pittsburgh, Pennsylvania, March 1984
- M.R. Genesereth: "Procedural hints in the control of reasoning", Massachusetts Institute of Technology, Boston, Massachusetts, March 1984
- M.R. Genesereth: "Procedural hints in the control of reasoning", I.B.M. Corporation, April 1984
- M.L. Ginsberg: "Probabilistic reasoning using Dempster's rule", SRI International, Menlo Park, California, June 1984
- B.N. Grosof: "An inequality paradigm for probabilistic reasoning", SRI International, Menlo Park, California, March 1984
- B.N. Grosof: "Default logic and default reasoning", Stanford University, Stanford, California, May 1984
- B.N. Grosof: "An inequality paradigm for probabilistic reasoning", Stanford University, Stanford, California, May 1984
- B.N. Grosof: "Default reasoning as circumscription", Stanford University, Stanford, California, May 1984

- D.E. Smith: "Domain independent control of reasoning", Computer Forum, Stanford University, Stanford, California, February 1984
- E.H. Shortliffe: Seminar on Knowledge Systems, The University of Utah, Salt Lake City, Utah, January 1984.
- E.H. Shortliffe: Annual Contractors' Meeting, Office of Naval Research, Stanford University, Stanford, Ca., January 1984.
- E.H. Shortliffe: Seminars on Expert Systems, Regional Meetings, Association for Computing Machinery, Colorado Springs and Denver, March 1984.
- E.H. Shortliffe: Tutorial on Explanation Capabilities for Expert Systems, American Association for Medical Systems and Informatics, San Francisco, May 1984.

SCHEDULE FOR NEXT QUARTER (JULY - SEPTEMBER)

Introspective Systems

Many of the projects begun earlier this year have natural extensions, and these are expected to comprise the bulk of our research effort over the next quarter. Specifically, the facilities within MRS for *inexact reasoning* will be expanded and applied on a larger scale; the compilers already in existence will be expanded, documented and released; general issues involving the cost of runtime control of reasoning will be investigated; and A Presentation Tool (APT), the implementation of our results on presentation, will be developed. We also expect to consider the problem of distributing deduction among many small processors, as opposed to a few large ones.

Work on the following problems is also envisioned: On the theoretical side, we expect to investigate an apparent connection between non-monotonic reasoning and the effectiveness of forward chaining. More practically, debugging tools will be developed for MRS, and a comparison will be drawn between DART's implementation in MRS and the earlier MYCIN program.

Explanation Project

In the next quarter, we expect to complete the following:

- John Kunz's dissertation will be printed and distributed to ONR contractors.
- Greg Cooper's thesis will be completed and submitted for printing.

- Glenn Rennels' influence diagram work will focus on writing and analysis rather than programming. His thesis proposal will be complete by the end of the summer, and we then expect his program development to resume on a full time basis.
- Curt Langlotz's simulation system on the Xerox 1108 should be complete in its first version and ready for us to undertake explanation experiments in the context of ONCOCIN.
- Shoko Tsuji's article on graphical access to the ONCOCIN knowledge based will be complete and submitted for publication.

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PROBLEMS ENCOUNTERED: none

DEPARTURES FROM PROPOSED WORK: none

ACTION REQUIRED BY THE GOVERNMENT: none

FISCAL STATUS:

(1) Currently provided on contract since January 1981: \$596,622

(2) Expenditures and commitments as of 6/30/84: \$475,451

(3) Funds required to complete work: \$492,919

Stanford SPO Reference No.: 11192-01-00

Michael R. Genesereth, Ph.D. Principal Investigator

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